(2) *Comment on Draft Article 10e, Names for primary divisions of genera.* By W.O. Cernohorsky *(Auckland Institute and Museum, Auckland, New Zealand)*

I am particularly concerned with the proposal in *Bull. zool. Nom.* vol. 35: 78 on the interpretation of Draft Article 10e, 'Names for primary divisions of genera'.

2. I would say that about 20 per cent of all molluscan generic names were proposed as secondary and tertiary divisions of genera, and such genus-group names, provided at least one nominal species-group taxon was associated with them, have always been considered by malacologists as validly established, provided that the genus-group name was properly latinised and met other requirements of availability. One could cite as a typical example Thiele's *Handbuch der systematischen Weichtierkunde,* 1929–1935, where the author recognises genera, subgenera and sections. Numerous new genus-group names have been proposed as 'sections' in this work, for instance:

: 324: Section *Proneritula* n. sect. Type species, by monotypy, *N. (P.) westerlundi* (Brusina)

: 333: Section *Olivellopsis* n. sect. Type species, by monotypy, *B. (O.) simplex* (Pease)

and there are many others.

3. Needless to say, if the word 'primary' were retained and strictly interpreted, the effect on molluscan nomenclature would be not merely disturbing, it would produce chaos. It should also be made clear that such a name, if meeting the other requirements for availability, and whether proposed generically, subgenerically or infrasubgenerically, for one or more species (the proposal mentions only 'a group of species') should be considered valid.

THE CASE FOR MULTIPLE TYPE SPECIMENS IN PARASITIC PROTOZOA. Z.N.(G.) 185

By P.C.C. Garnham, R.S. Bray and R. Killick-Kendrick *(Imperial College Field Station, Ashurst Lodge, Ascot, Berks SL5 7DE, U.K.)*

For the past seven years or more, protozoologists have expressed a desire for a change in the Code in special connection with Articles 72–74. The present situation is that it is practically

impossible to designate a single individual as the type of a species, particularly in the Class formerly known as the Sporozoa and now termed Apicomplexa (Levine, 1970). This group includes the economically and medically important malaria parasites, coccidia and piroplasms.

2. Accordingly, in 1977, the International Commission on Protozoology, during the V International Congress of Protozoology in New York, appointed a committee to consider the question and propose amendments to the Code. The report of this committee was approved by the International Congress of Parasitology in Warsaw in September 1978 and is published in *Bull. zool. Nom.* vol. 35: 200–208.

3. There is little doubt that the unsuitability of Chapter XVI of the Code has been responsible for the reluctance of most protozoologists to deposit type specimens in museum collections (Garnham, 1977). There exists a very special need for a base line from which to compare species and subspecies, and a single individual or even a clone of a number of individuals on a slide is often insufficient for the identification of the species. The suggested changes in the Code do not imply that the types of all new species of protozoa must be multiple (hapantotypes); but in species with complicated life cycles, the essential criteria for identification are in many cases multiple and only to be seen in preparations showing different stages – which, however, must be directly related. It is only the combination of characters that enables a species to be defined and firm identifications to be made. It is seldom that a single individual will suffice in the Apicomplexa.

4. In most cases, it is necessary to have several directly related stages before a type can be designated. In the genus *Plasmodium* it is impossible to construct a running synoptic key and instead, as in botany, a tabular key is necessary where, for example, given 12 features, one species possesses five and another seven, but the two that differ are shared by a third species with nine of the features but lacking a feature common to the first two species. Here a multiple type specimen is necessary.

5. Few type specimens have been designated in the past, and so little original material exists that neohapantotypes are necessary for most of the organisms. There seems no reason why the neohapantotype should not include characters not noted by the original observer, but that became obvious later when the multiple stages of the life cycle had been worked out.

6. In the groups with which we are here concerned, there must be many hundreds of species for which types should be deposited, so that comparisons are possible and exact identifica-

tions can be made. The *material itself* is necessary; the *original description* alone may be inadequate: a feature subsequently recognised as having critical importance may have been overlooked. If the original type slide is available, a comparison can be made. For example, when Schwetz described *Plasmodium fallax* in 1930, he made no mention of vacuoles. These were subsequently found to be characteristic of the species and enabled *P. gundersi* to be differentiated from it; in all other respects the two species are identical (Bray, 1962). If the description alone had been available, it would have been impossible to make the distinction. Fortunately, in this case Schwetz's original material was extant. This is an instance where a single, suitably chosen preparation might well serve the function of a type.

7. There are very many examples of species that need a combination of characters of different stages for their identification. Five are given below:

(1) *Plasmodium ovale* Stephens, 1910, and *P. vivax* (Grassi & Felletti, 1890): The blood stages of these two parasites may look the same, and for 20 years Wenyon refused to accept the validity of the former; then in 1932 James and others demonstrated a characteristic difference in the morphology of the respective oocysts in the mosquito host (a different type of pigment distribution) and later still (Garnham and others, 1955) the exoerythrocytic stages in the parenchyma cells of the liver of man were also found to be different. However, neither the mosquito stages nor the liver stages alone would be sufficient for identification, for other parasites show similar features, although in them the blood stages differ.

(2) The identification of the rodent malaria parasites depends very much on a comparison of the features in the exoerythrocytic and sporogonic stages; the blood forms may be identical. For example, the blood forms of *P. berghei* and *P. yoelii* are indistinguishable, but the species can be recognised by the length of the sporozoites (Killick-Kendrick, 1974). But a sporozoite alone cannot satisfactorily be used as a type specimen because it could not be distinguished from a sporozoite of many other species of malaria parasites. The sporozoite only has value if it has been shown to have arisen from a parasite with the characteristics of the *berghei* group. The separate identities of *P. berghei* and *P. yoelii* are now generally accepted not solely on the length of the

sporozoites, but also on the rate of growth and morphology of the exoerythrocytic schizonts, and the size of the mature oocyst. Marked differences in isoenzymes (Beale and others, 1978) offer another critical feature for differentiating these two species and others in the *berghei* species-complex.

(3) Subspecific differences are often only revealed by observing the complete life cycle. *Plasmodium relictum matutinum* can only be differentiated from *P. r. relictum* by the presence of characteristic vacuoles in the cytoplasm of phanerozoites in the former (Corradetti and others, 1962); similar vacuoles are found in *P. gallinaceum,* but the blood stages are different – so here again it would be impossible to select a phanerozoite alone as the type specimen.

(4) Characteristic features may not be apparent in a single blood film. Thus, typical schizonts may be present on one day, typical trophozoites on another, and typical gametocytes on yet another, e.g. in *P. falciparum* and *P. cathemerium.* Also the typical quartan, tertian, or quotidian course of development in the blood (from the ring stage to the mature schizont in the phase of asexual multiplication) will only be revealed by examining successive specimens at daily intervals for at least four days. This is a critical distinction between *P. knowlesi* one day) and *P. coatneyi* (two days) where the morphology of the blood forms may be indistinguishable (though in other species the blood stages may be distinctive).

(5) The isosporan coccidial parasites, formerly placed in the Toxoplasmatea, present a particularly difficult problem, owing to the fact that their two stages, in different hosts, had been placed in separate genera (see Levine, 1977). This is a separate problem, but the hapantotype concept is also involved, because identification of the species again depends upon the morphological characters of both stages. Thus from a genus *(Sarcocystis)* with two hosts and distinctive stages in each, let us take three species, A, B and C. In one host (a prey host), A and B are morphologically indistinguishable but C is different; while in the second host (a predator host), A and C are indistinguishable but B is different. It therefore requires both forms to define the species and a multiple type specimen is necessary. This is illustrated in the following table:

Parasite species	Sarcocyst in prey host	Sporocyst in predator host
A. *Sarcocystis muris*	thin walled (in the mouse)	8.5 x 10.3μm (in the cat)
B. *S. cruzi* (synonym *S. bovicanis)*	thin walled (in the ox)	10.8 x 16.3μm (in the dog)
C. *S. hirsuta* (synonym *S. bovifelis)*	thick walled (in the ox)	7.8 x 12.5μm (in the cat)

In the first two parasites the sarcocysts in the prey are indistinguishable by light microscopy and in the first and last the range of measurements of the sporocysts in the predator overlaps.

8. It is therefore our contention that most species in the Apicomplexa cannot be defined by reference to a unique type specimen and that a multiple type specimen is essential to the definition of what are perfectly good species. We prefer the hapantotype concept to any system based on a holotype supported by paratypes, or on syntypes, because we frequently find that a single preparation may contain a number of organisms, each indispensable and of equal importance in the definition of the species.

REFERENCES

BEALE, G.H., CARTER, R. & WALLIKER, D. 1978. Genetics, Chapter 5 in *Rodent malaria* (Killick-Kendrick & Peters eds.) Academic Press, London, 406 pp.

BRAY, R.S. 1962. On the parasitic protozoa of Liberia. VII. Haemosporidia of owls. *Arch. Inst. Pasteur Algérie*, vol. 40: 201–207

CORRADETTI, A., MORCOS, W.M. & NERI, I. 1962. Sulla produzione di forme endoistocitarie nei canarini infettati con il ceppo italiano di *Plasmodium matutinum* derivato di *Turdus iliacus. Parassitologia*, vol. 4: 105–108

GARNHAM, P.C.C., BRAY, R.S., COOPER, W., LAINSON, R., AWAD, F.I. & WILLIAMSON, J. 1955. The preerythrocytic stage of *Plasmodium ovale. Trans. roy. Soc. trop. Med. Hygiene*, vol. 47: 158–167

GARNHAM, P.C.C. 1969. The preservation of type specimens of protozoa with special reference to the Haemosporidia. *Parassitologia*, vol. 11: 1–8

JAMES, S.P., NICOL, W.D. & SHUTE, P.G. 1932. *Plasmodium ovale* Stephens: passage of the parasite through mosquitoes and successful transmission by their bite. *Ann. trop. Med. Parasitol.*, vol. 26: 139–145

KILLICK-KENDRICK, R. 1974. Parasitic protozoa of the blood of rodents. I: The life-cycle and zoogeography of *Plasmodium berghei nigeriensis* subsp. nov. *Ann. trop. Med. Parasitol.*, vol. 67: 261–277

LEVINE, N. 1970. Taxonomy of the protozoa. *J. Parasitol.*, vol. 56(II): 208–209

——— 1977. Nomenclature of *Sarcocystis* in the ox and sheep and of faecal coccidia of the dog and cat. *J. Parasitol.*, vol. 63: 36–51